



Future ATM Concepts Evaluation Tool (FACET) Background, Capabilities and Plans

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Background

- **Conducting research in En Route and TFM as part of AATT and VAMS**
- **Developed a modeling and simulation capability: Future ATM Concepts Evaluation Tool (FACET)**
- **Capability useful for both real-time applications and off-line analysis**
- **FACET has been provided to FAA, industry, small companies and universities**
- **Working with the airlines and FAA to customize the capability for specific uses**



Outline

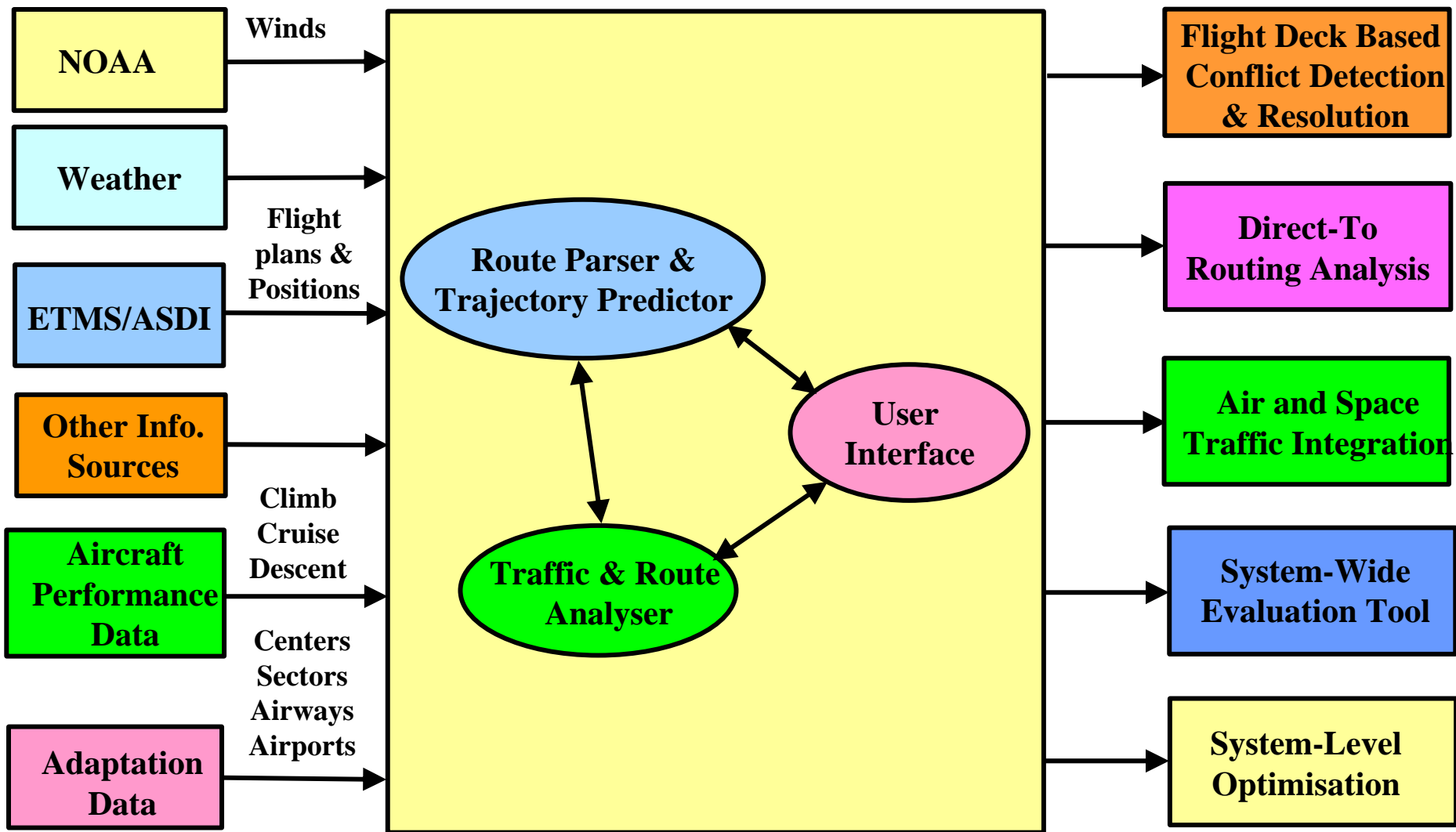
- **FACET Simulation and Modeling Capability**
- **Applications**
- **Current Plans**
- **Research Directions**



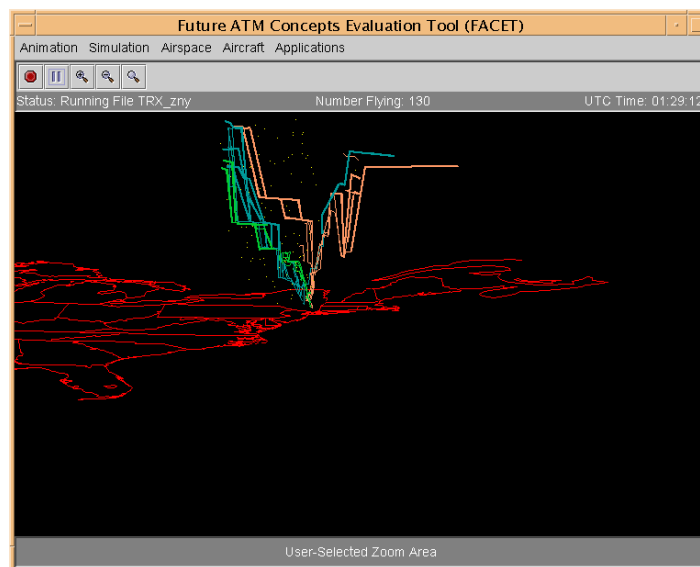
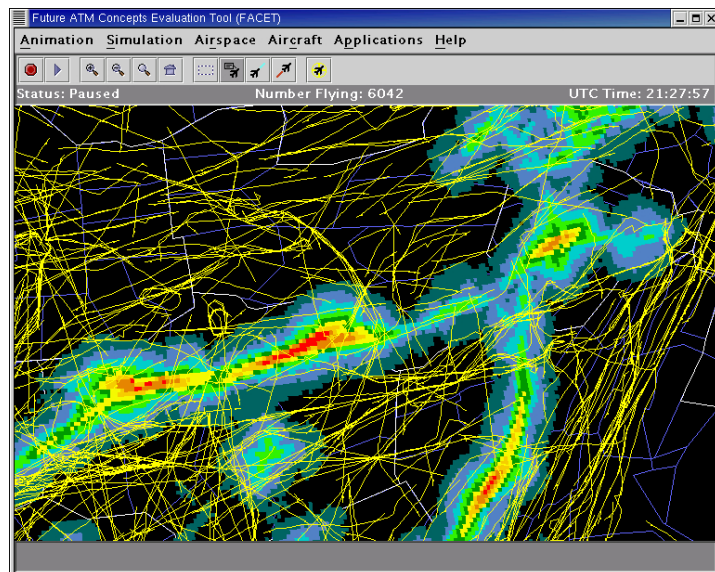
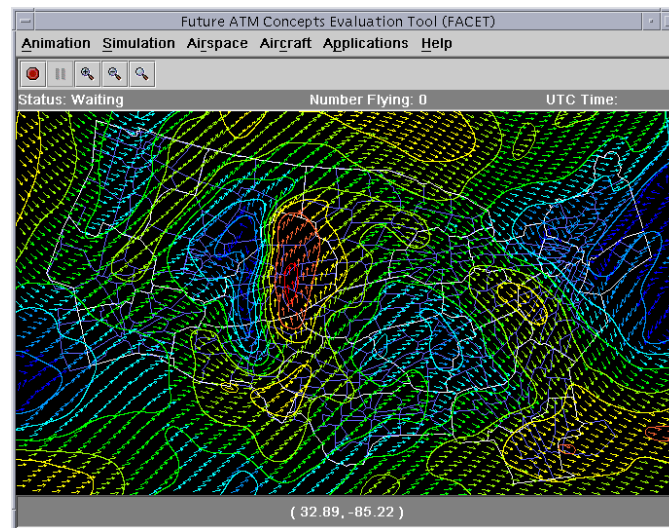
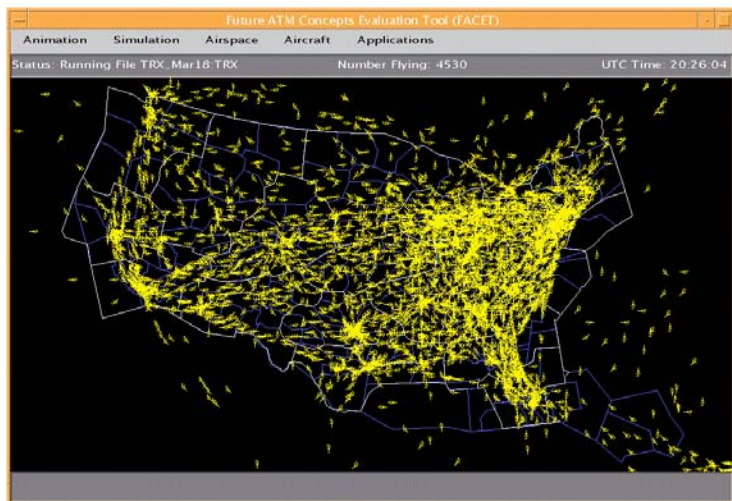
Future ATM Concepts Evaluation Tool (FACET)

- **Simulation tool for exploring advanced ATM concepts**
- **Balance between fidelity and flexibility**
 - Model airspace operations at U.S. national level (~10,000 aircraft)
 - Modular architecture for flexibility
 - Software written in “C” and “Java” programming languages
 - » Easily adaptable to different computer platforms
 - » Runs on Sun, SGI, PC and Macintosh computers
- **Used for visualization, off-line analysis and real-time planning applications**

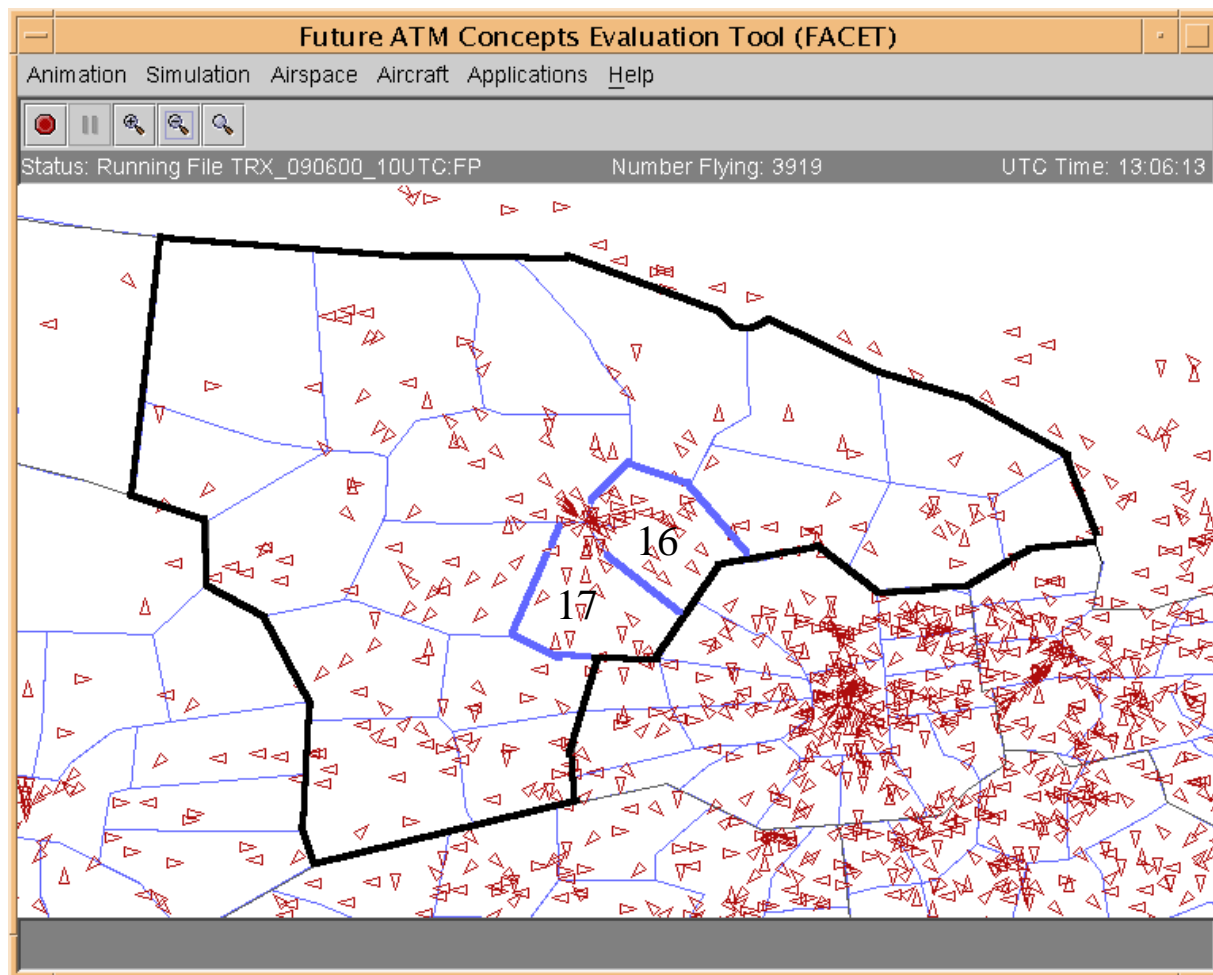
FACET Architecture



FACET Display

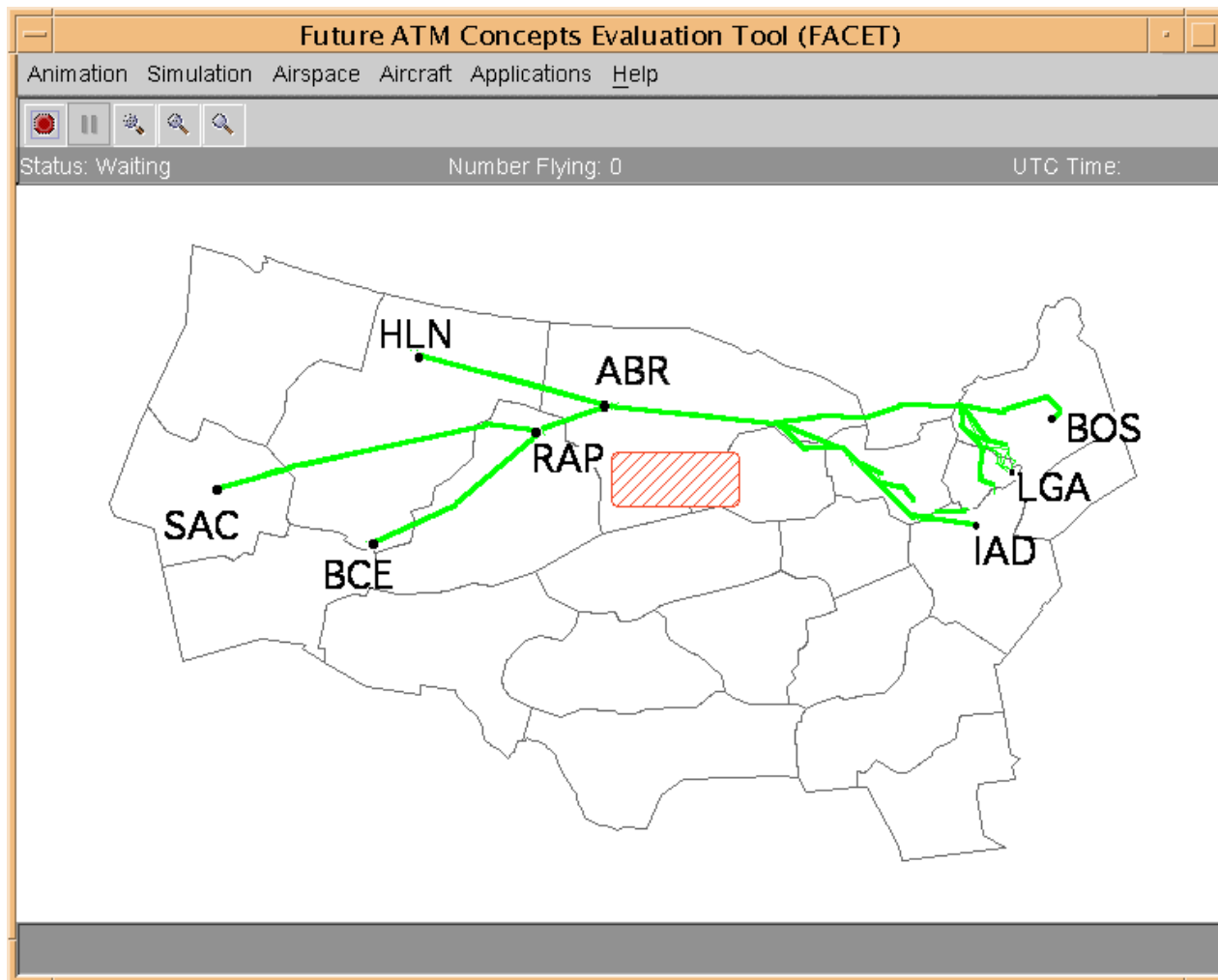


FACET Display

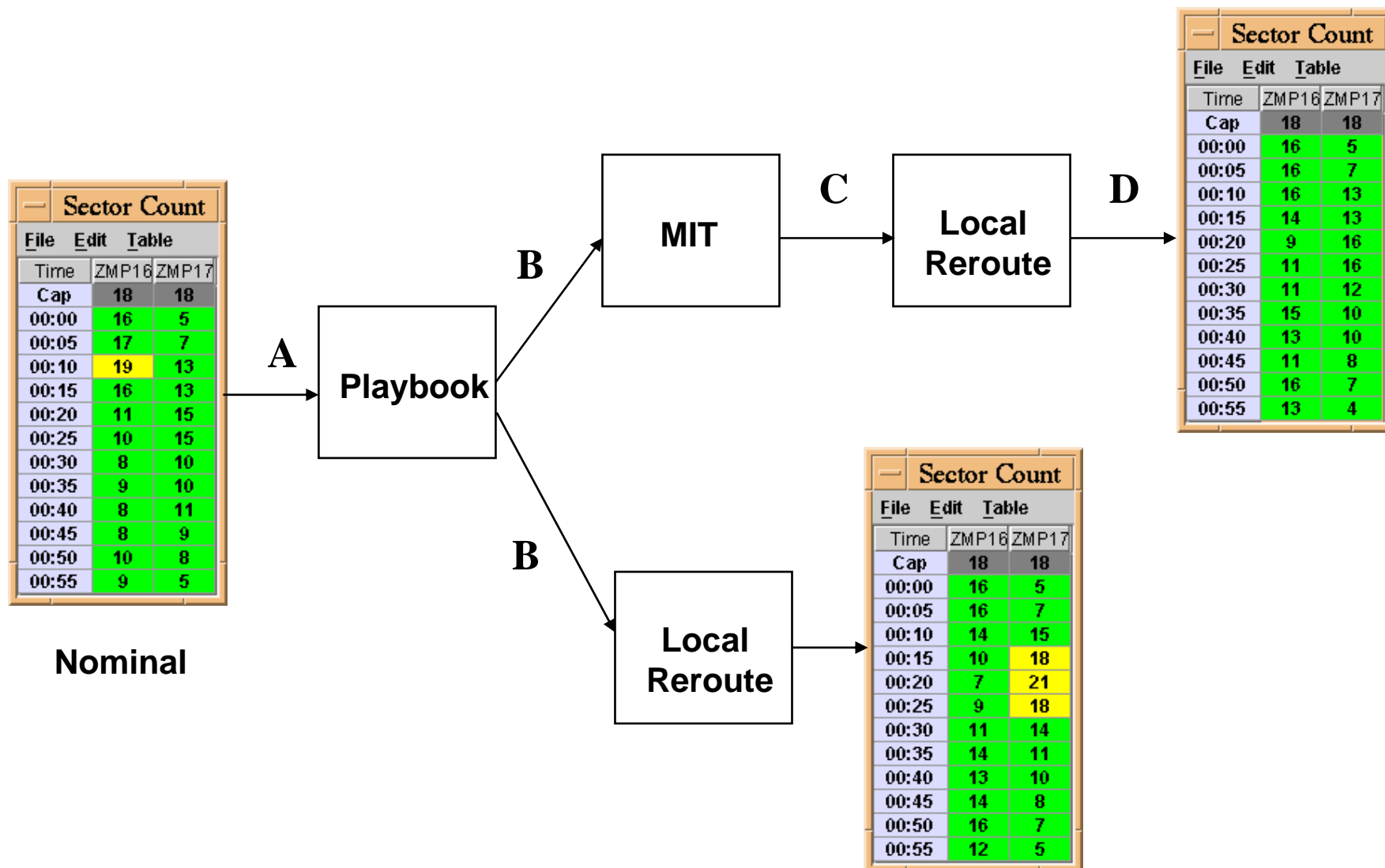


Sector Count		
File	Edit	Table
Time	ZMP16	ZMP17
Cap	18	18
00:00	16	5
00:05	17	7
00:10	19	13
00:15	16	13
00:20	11	15
00:25	10	15
00:30	8	10
00:35	9	10
00:40	8	11
00:45	8	9
00:50	10	8
00:55	9	5

West Watertown Playbook Reroutes

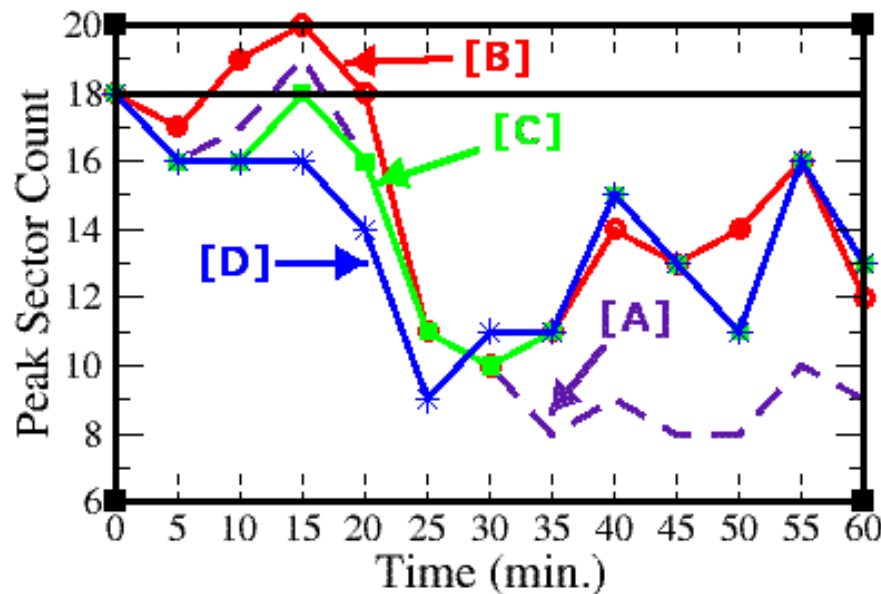


Alternative effects of TFM actions



Integrated traffic counts in ZMP Sector 16

[A] Nominal Counts, [B] Playbook Reroute,
[C] Playbook + MIT, [D] Playbook + MIT+Local Reroute.

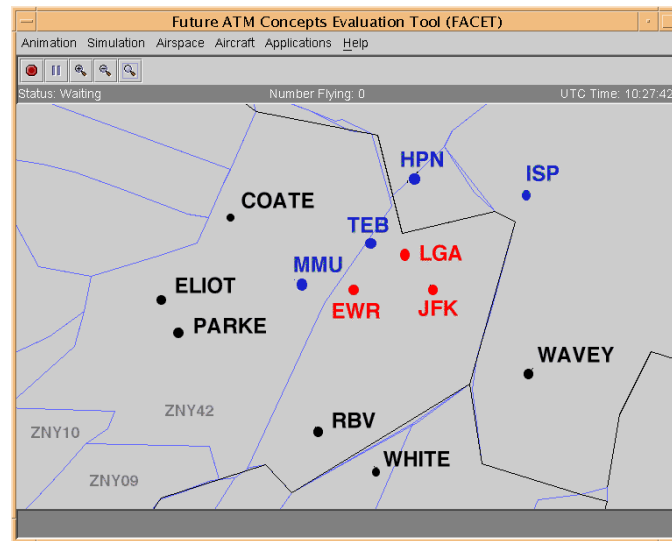


	Impacted Aircraft Count	Total Delay (min)	Average Delay (min)
Playbook	48	1448	30.16
MIT	18	48	2.69
Local Reroute	4	8.0	2.0

B. Sridhar, G.B. Chatterji and S. Grabbe, Integration of Traffic Flow Management Decisions, Proceedings of AIAA Guidance, Navigation and Control Conference, Aug. 5-8, 2002, Monterey, CA

Traffic Management Scenario

- Each day volume at Chicago (ORD) airport leads to Chicago ARTCC (ZAU) and Cleveland ARTCC (ZOB) to place restrictions on all aircraft landing at O'Hare at specified times
- Restrictions passed on to New York ARTCC (ZNY)
- ZNY passes the restriction to New York TRACON (N90)
- Scenario uses all restrictions in effect 6/27/02
 - Focus on traffic from ZNY to ORD, CLE, and ATL



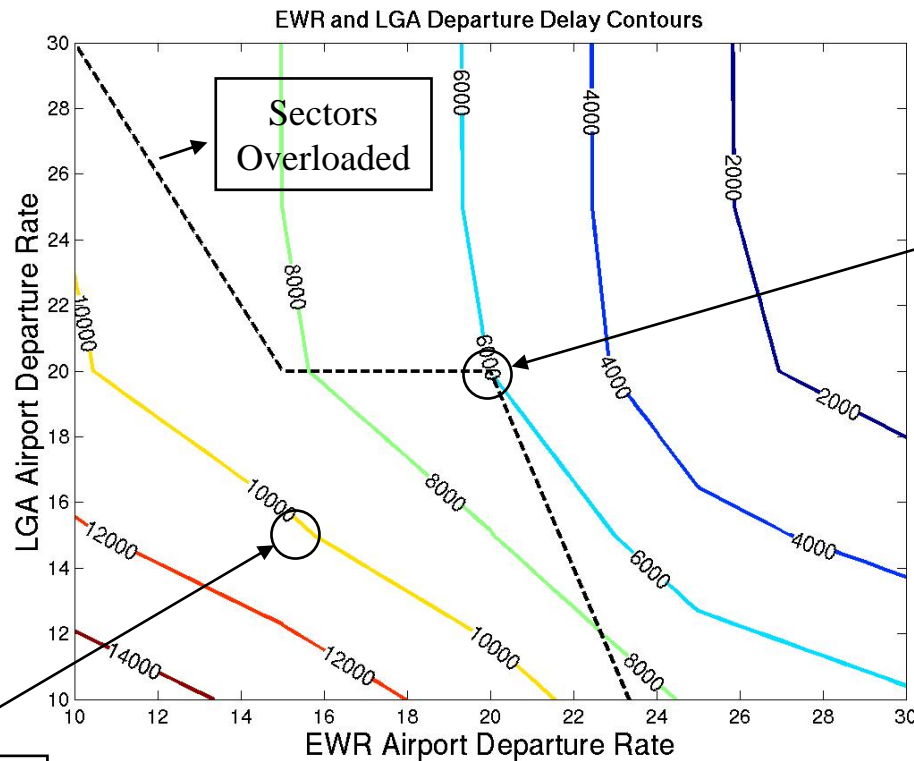
S. Grabbe and B. Sridhar, Modeling and Evaluation of Miles-in-Trail Restrictions in the National Airspace, Proceedings of AIAA Guidance, Navigation and Control Conference, Aug. 11-14, 2003, Austin, TX.



Alternative Impact Assessment Capabilities

Sector ()		
File Edit Table		
Time	ZNY34	ZNY10
Cap	17	17
13:06	15	9
13:21	14	12
13:36	13	14
13:51	12	10
14:06	11	11
14:21	9	8
14:36	12	11
14:51	11	16

[A] Rerouting + Nominal
Departure Rates
Total Delay = 10361 sec.



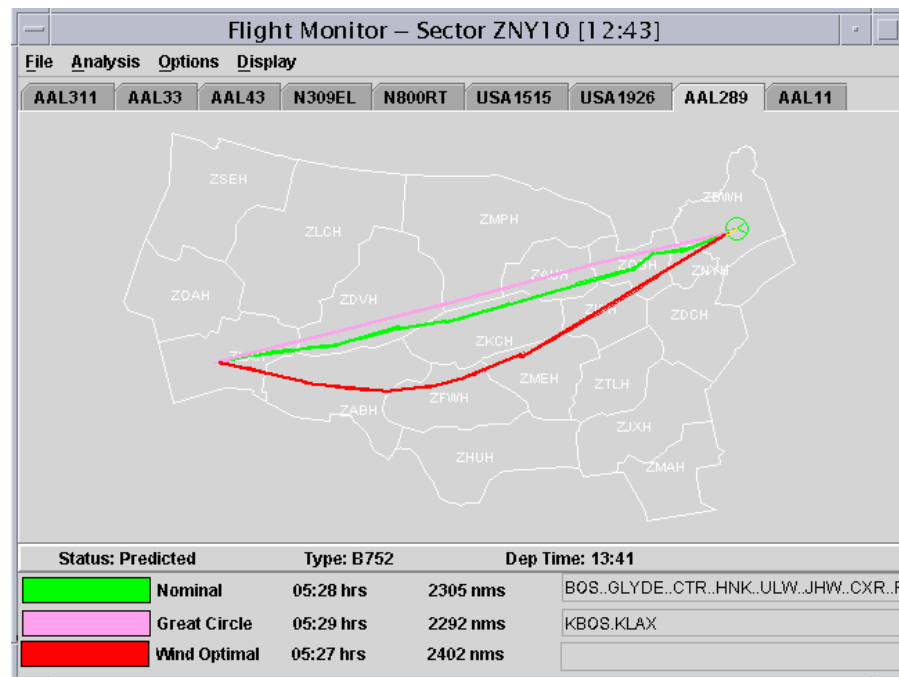
[B] Rerouting + Optimal
Departure Rates
Total Delay = 5986 sec.

Sector ()		
File Edit Table		
Time	ZNY34	ZNY10
Cap	17	17
13:06	16	9
13:21	15	12
13:36	13	14
13:51	13	11
14:06	13	10
14:21	13	8
14:36	15	11
14:51	8	16

System demand is met with minimum delay

FACET-AOC

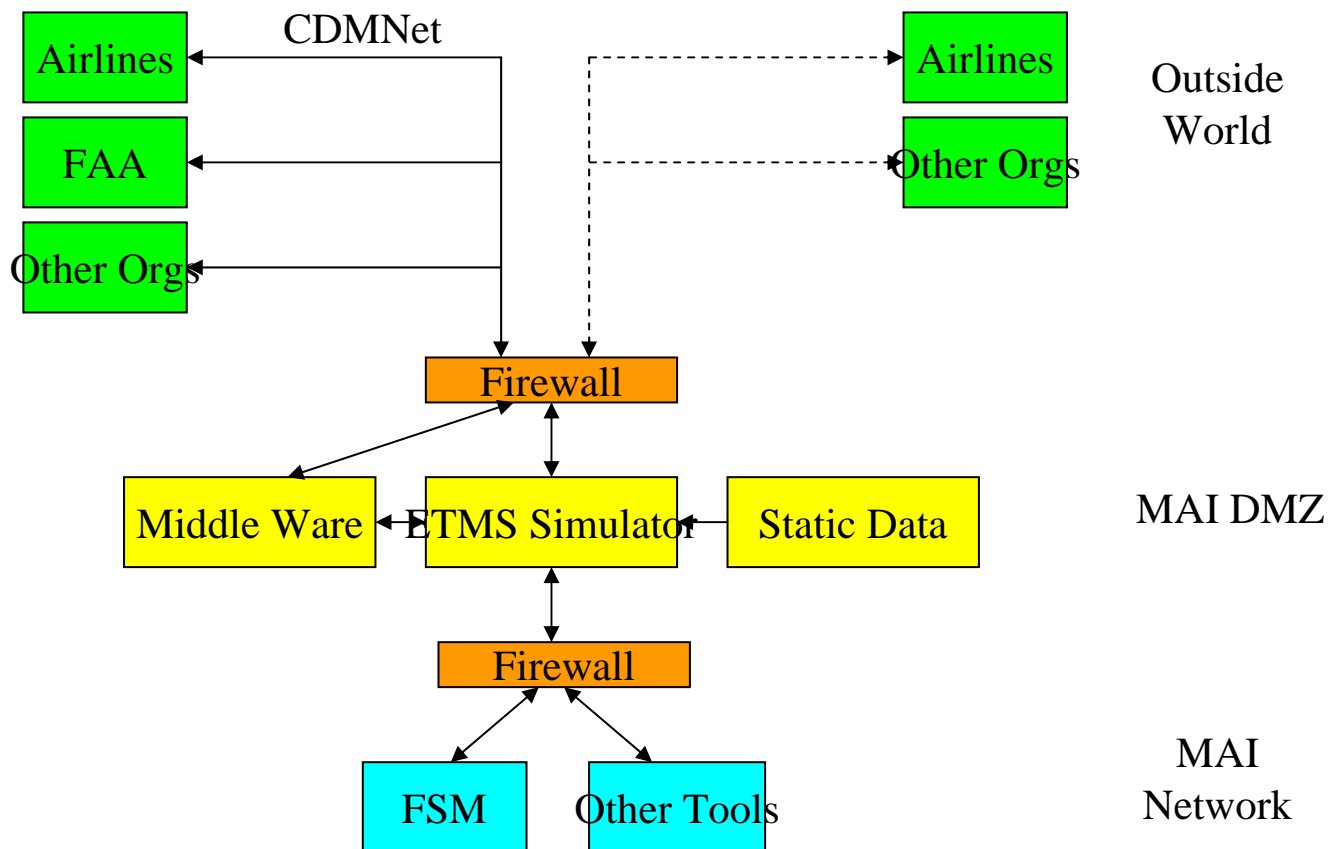
- **March 2001: request by ADF team to increase NASA research**
- **FACET modified to work with ASDI data**
- **Working with ADF and Ohio State University to develop requirements and identify research issues**
 - Dispatcher input on functionality (October 21-23 at OSU)
 - Interviews/Training for dispatchers at NWA, SWA



- Develop functional requirements for a version of FACET for AOC use
- Integration of FACET with CWIS weather at NWA
- Working with Flight Explorer to transfer the technology to the users



Integration of FACET with Jupiter Simulation Environment (JSE)



- HITL simulation environment to examine new CDM concepts and support the collaborative process
- Working with Metron and FAA to provide the en route and TFM modeling, analysis and display capabilities using FACET



Research Directions/ Lessons from FACET Development

- **Standardization and accuracy of data**
- **Integration with other tools/systems**
- **Dealing with Uncertainty**
- **Traffic Flow Models**

G. Chatterji and B. Sridhar, Analysis of ETMS Data Quality for Traffic Flow Management Decisions, Proceedings of AIAA Guidance, Navigation and Control Conference, Aug. 11-14, 2003, Austin, TX

S. Roy, B. Sridhar and G. Verghese, An Aggregate Dynamic Stochastic Model for an Air Traffic System, 5th USA/Europe Conference on Air Traffic Management, Budapest, Hungary, June 23-27, 2003.



Additional Slides



FACET Applications

- **Conflict Detection and Resolution**
- **Direct-to Benefits Study**
- **Dynamic Density Studies**
- **Regional Metering**

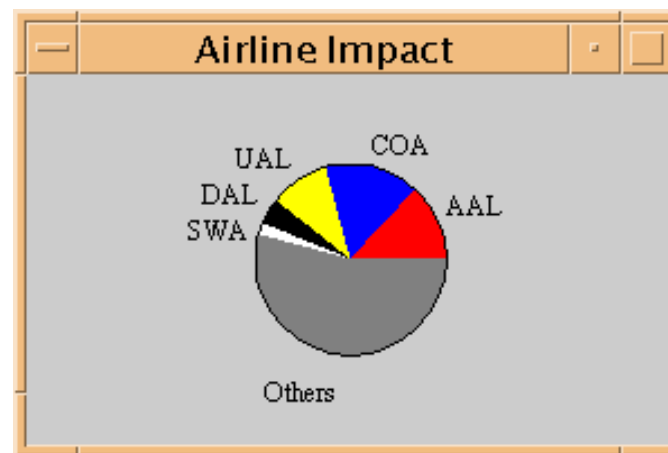
System-Wide Evaluation and Planning Tool (SWEPT)

- **SWEPT= FACET + Requirements and Modifications for FAA use**
- **Conducted interviews with TFM specialists to assess the feasibility of using FACET capabilities**
- **SWEPT envisioned to be a research capability for evaluating, monitoring, and analysing TFM initiatives, operational procedures, and traffic flow scenarios.**
- **SWEPT has been demonstrated to SCC and CDM; FAA has recommended setting up a conformance monitoring user group for SWEPT.**
- **Working with Volpe in the development of SWEPT**
 - **Integration with “Live” ETMS**
 - **Re-organization of functions from a user’s perspective**
 - **Modifications to enable a “plug-and-play” with TFM infrastructure**
 - **Real-time reroute conformance monitoring**

Impact of alternative ELIOT and PARKE Restrictions from 10:30 - 13:30 UTC

Restriction	Impacted Aircraft Count	Total Delay (min.)	Avg. Delay (min.)	ZNY10 Congested?
ELIOT – 10 MIT PARKE – 10 MIT	124	1030	8.3	NO
ELIOT – 10 MIT PARKE – 15 MIT	124	1741	14.0	NO
ELIOT – 15 MIT PARKE – 10 MIT	124	1940	15.6	NO
ELIOT – 15 MIT PARKE – 15 MIT	124	2651	21.4	NO

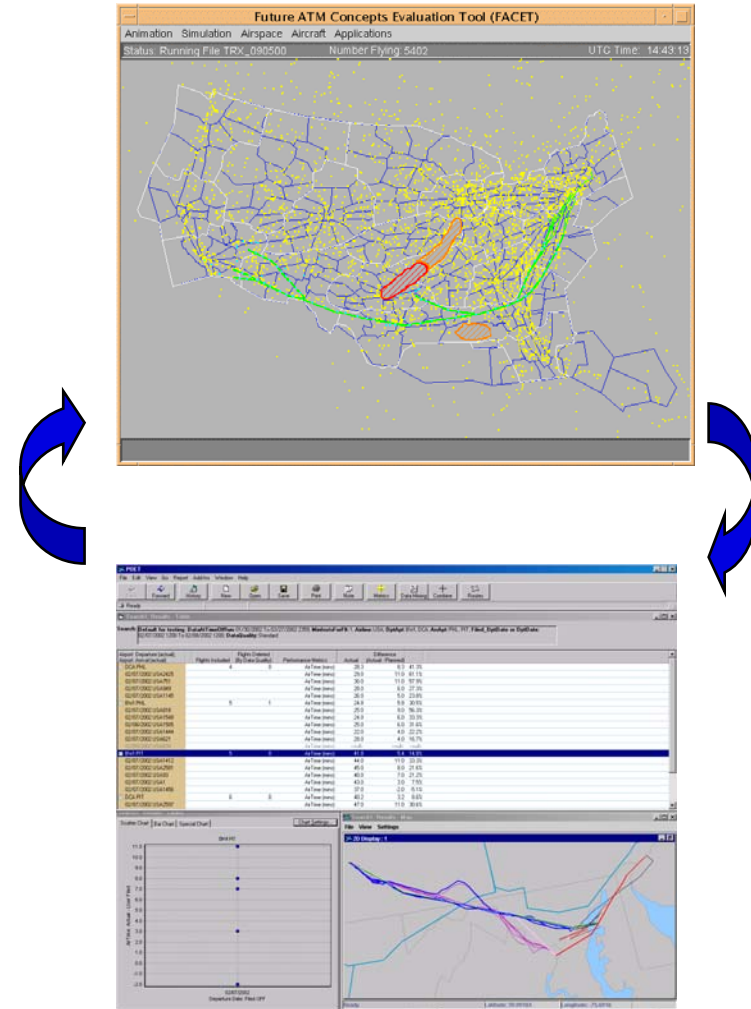
Acid	Rerouted	Metered	GDP/GS
AAL1		X	
AAL1003		X	
AAL1097		X	
AAL1143		X	
AAL1171		X	
AAL1343		X	
AAL157		X	
AAL1721		X	
AAL1893		X	
AAL2501		X	
AAL255		X	
AAL281		X	



Actual Restriction on June 26, 2002: ELIOT-15 MIT, PARKE-15 MIT

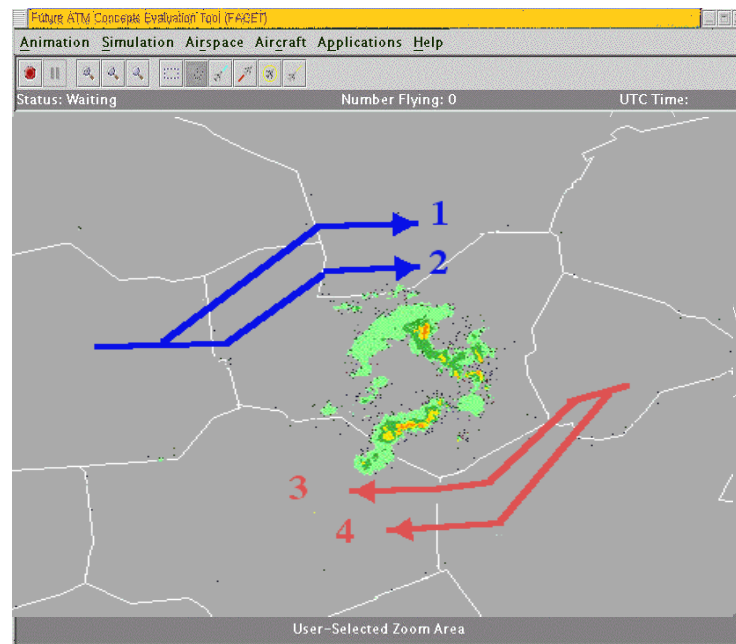
FACET-POET Integration

- **Phase 1 SBIR Project with Metron Aviation, Inc.**
- **Leverage Existing Technologies to Perform New Tasks**
 - POET provides Operational Analysis and Historical Database.
 - FACET provides Modeling and Simulation Capabilities.
- **Integrated system can be used for real-time decision making or post-operations analysis.**
 - Allows assessment of alternative TFM initiatives before implementation.
 - Historical events can be re-evaluated with alternative constraints.



Collaborative Routing Resource Allocation Tool (CRRAT)

- **Phase 2 SBIR Project with Metron Aviation, Inc.**
- **CRRAT will add en route resource allocation functionality to NASA's FACET.**
- **Goal of the project is to perform and evaluate proposed en route resource rationing schemes.**
 - Grover-Jack
 - Time-Ordered Accrued Delay (TOAD)
 - Ration-By-Schedule (RBS)
- **CAART will utilize the following control actions for alleviating en route congestion:**
 - Rerouting
 - Altitude Changes
 - Departure Delays
 - Speed Adjustments





Collaboration in the development of FACET/SWEPT

- **FAA**
 - Access to ETMS feed, facilities and operations people, Analysis using FACET (AOZ-40, ASD-130, ACT-540)
- **Volpe**
 - ETMS expertise, review of user interface, requirements
- **Metron**
 - Use of FACET for TFM tasks; Analysis using FACET
- **CSC**
 - Integration with DSP
- **ADF and Ohio State University**
 - AOC requirements, Research issues in PTFM
- **MIT Lincoln Laboratory**
 - Use of CWIS in tactical and strategic planning
- **CAASD**
 - General interaction as part of IAIP- review of sources of prediction errors, evaluating FACET for OEP analysis